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Duration: 3 hours

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1. Each of a proposed three-phase 1200-kV, 600 kilometers transmission line consists of a conductor bundle composed of 12 solid conductors symmetrically spaced around a circle 100 cm in diameter. Each conductor has a diameter of 1.2 cm. Each phase bundle is placed in a corner of an equilateral triangle of 15 m side.
 - (a) If the resistance of each phase is 0.0384 Ohms per kilometer, find the ABCD constants of the line.
 - (b) If the load on this line is 6500 MW at 1200 kV and 0.8 power factor lagging, find the line efficiency.
 - (c) Determine the wavelength and velocity of propagation of the line.
2. For the purpose of this problem ONLY, represent the equivalent circuit of the transmission line of Question 1 by the Π model.
 - (a) How many MVAR would this line produce?
 - (b) Determine the size of two banks of shunt reactors to be placed at each end and having the exact MVAR rating to reduce the line reactive generation to 40% of its original value.
 - (c) We wish also to reduce the series reactance of this line by 40% per phase by inserting series capacitors in each phase. Determine the capacitance per phase that must be installed in order to accomplish the desired compensation.
3. Draw the one line reactance diagram for the power system shown in Fig. 1. Select 1000 MVA base and 12 kV base at Generator 2.

G_1 , 400 MVA, 26 kV, $x = 0.8 \text{ p.u.}$

G_2 , 600 MVA, 13 kV, $x = 0.8 \text{ p.u.}$

G_3 , 500 MVA, 18 kV, $x = 1.0 \text{ p.u.}$

T_1 , 400 MVA, 26/500 kV, $x = 0.1 \text{ p.u.}$

T_2 , 700 MVA, 13/500 kV, $x = 0.1 \text{ p.u.}$

T_3 , 600 MVA, 18/500 kV, $x = 0.1 \text{ p.u.}$

$T.L_{AB}$, $x = j50 \Omega$

$T.L_{BC}$, $x = j40 \Omega$

$T.L_{AC}$, $x = j60 \Omega$

Z_L , $0.05 + j0.2 \Omega$

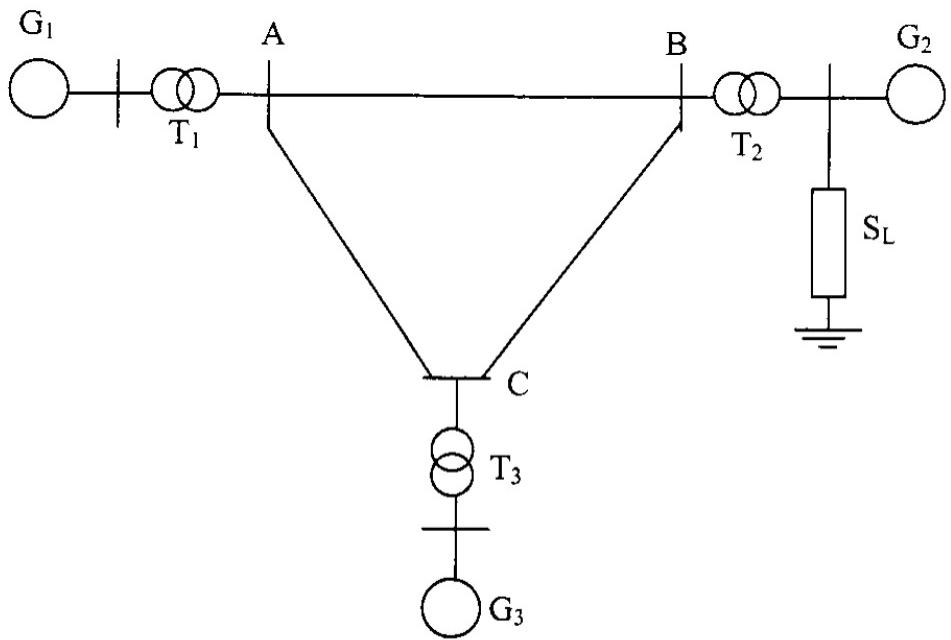


Fig. 1

4. Consider the sample power system shown in Fig.2. All reactances are in per unit. Find the bus impedance matrix Z_{bus} .

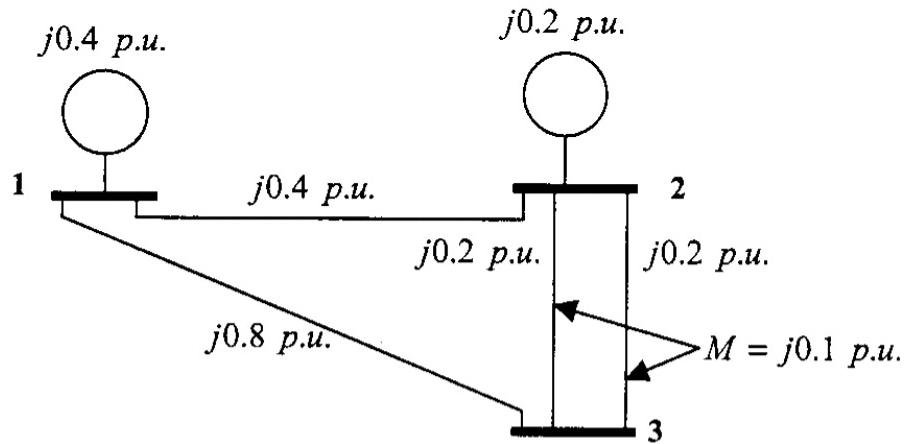


Fig. 2

5. Consider the two-bus system shown in Fig.3. The load $S_L = 5 + j4 \text{ p.u.}$ is supplied by the generator via the line. The line is represented by an equivalent π network, the impedances of which are as follows:

$$Z_s = 0.01 + j0.05 \text{ p.u.}$$

$$Z_p = -j3 \text{ p.u.}$$

The generator reactance is $X_g = j1.0$ p.u. The magnitude $|V_2|$ of the voltage of bus 2 must equal 1.0 p.u. Determine:

- The voltage that we must maintain at bus 1 in order to achieve the above objective.
- The required active and reactive generation (P_G & Q_G).

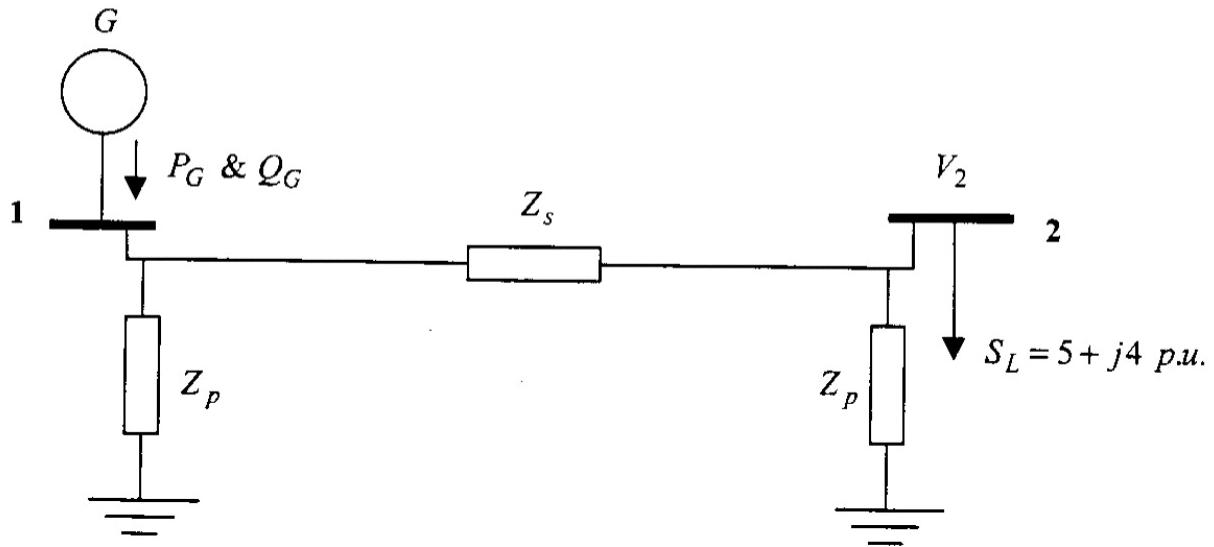


Fig. 3